

# Just in Time Assurance

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# Weinberg's Second Law

“If builders built buildings the way programmers wrote programs, then the first woodpecker that came along would destroy civilization.”

- Anyone can get a system certified with enough time, money, threats, and waivers
- It takes skill to design a system that is practical and affordable to certify
- It takes a virtuoso to design a system that is practical and affordable to recertify given unpredictable but inevitable obsolescence events
- ***This presentation discusses how practical and affordable recertification can become the norm instead of the rare exception***



# What Does Just in Time Mean?

- Manufacturing:
  - Parts arrive only when needed because inventory is waste.
    - Requirement: Quick notice of stock depletion
- Assurance:
  - Only modified components are reevaluated because total system reevaluation is waste.
    - Requirement: **NEAT** system architecture



# What is NEATness?

- **N**on-bypassable:
  - The infrastructure guarantees critical reference monitors in information flow paths can't be circumvented
- **E**valuatable:
  - Each critical reference monitor is small and simple enough to enable unambiguous specification and rigorous evaluation
- **A**lways Invoked:
  - Critical reference monitors enforce their **local** security policy for every object they manage
- **T**amper Proof:
  - The infrastructure guarantees subversive agents can't modify any critical reference monitor's security functions or data.



# Local Security Policy Enforcement

**“Critical reference monitors enforce their *local* security policy for every object they manage”**

- Why the *local*?
  - A reference monitor should not know anything about any other part of the system
  - Reference monitor scope is constrained to the objects it manages
- A local reference monitor can be maintained, updated, and replaced with minimal effect on the rest of the system
  - A firewall or controlled interface in an enterprise network should not have knowledge about anything other than the policy it must enforce
  - A reference monitor in a real-time embedded system should not have knowledge about the specific platform on which it has been deployed
- A system can be certified, deployed, updated, recertified, and redeployed with reevaluation required only for the new components
- **RESULT:** the cost spiral caused by obsolescence events can be controlled



# NEATness Verification

- Provide assurance that the infrastructure has security properties that protect reference monitors from **TIME** events
- **TIME**:
  - **T**ype safety violation
  - **I**nfiltration violation
  - **M**ediation violation
  - **E**xfiltration violation



# TIME: Type Safety Violation

- When an object of one type is expected, a different type is delivered
- Consequences:
  - Buffer overflow
  - Address redirection
  - Unauthorized configuration modification
  - Activation of unintended code
    - Mission software turned into malware
    - Virus contagion
    - Root kit injection
    - Access control bypass



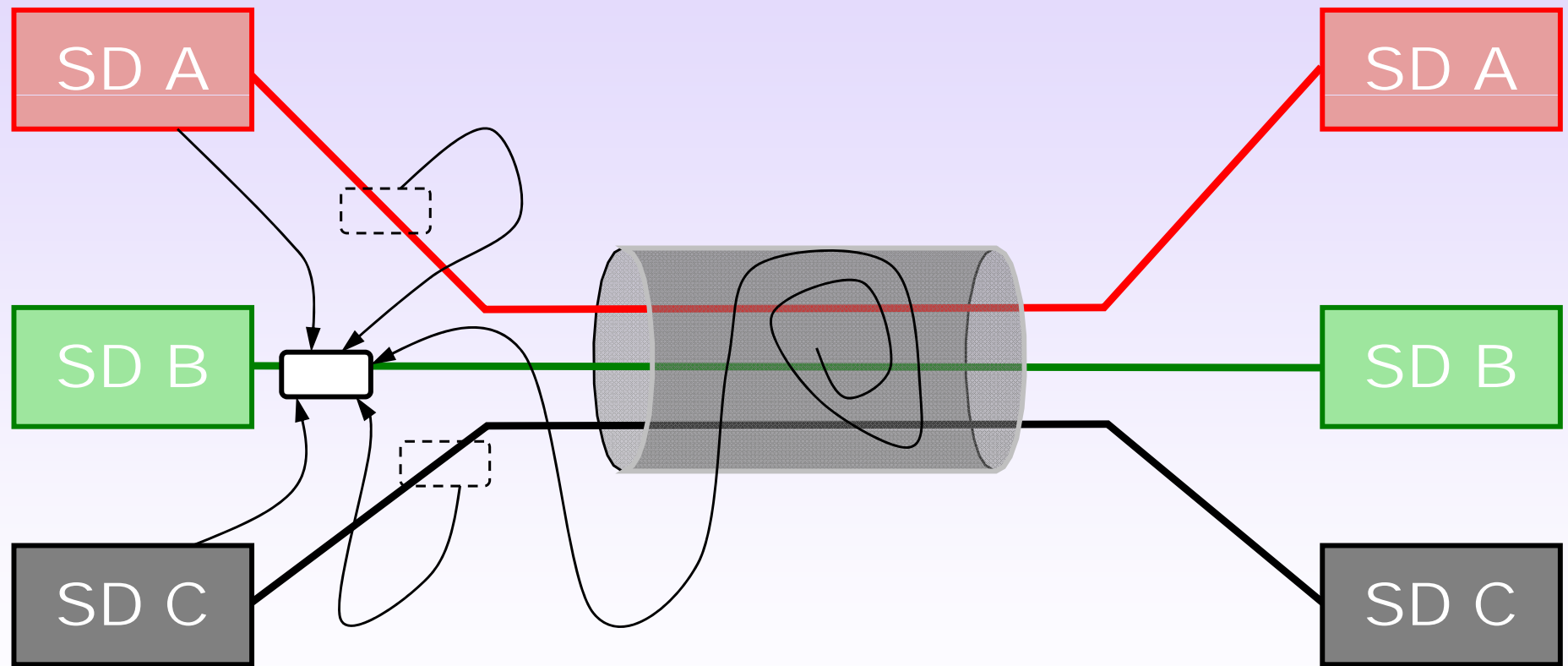
# T|ME: Infiltration

An unauthorized party may insert data into a channel, compromising integrity

- Party 1: An entity not authorized to send content on certain channels
- Party 2: Software, hardware, or systems that can attempt modification of traffic on certain channels but are not authorized to send content on those channels



# Infiltration

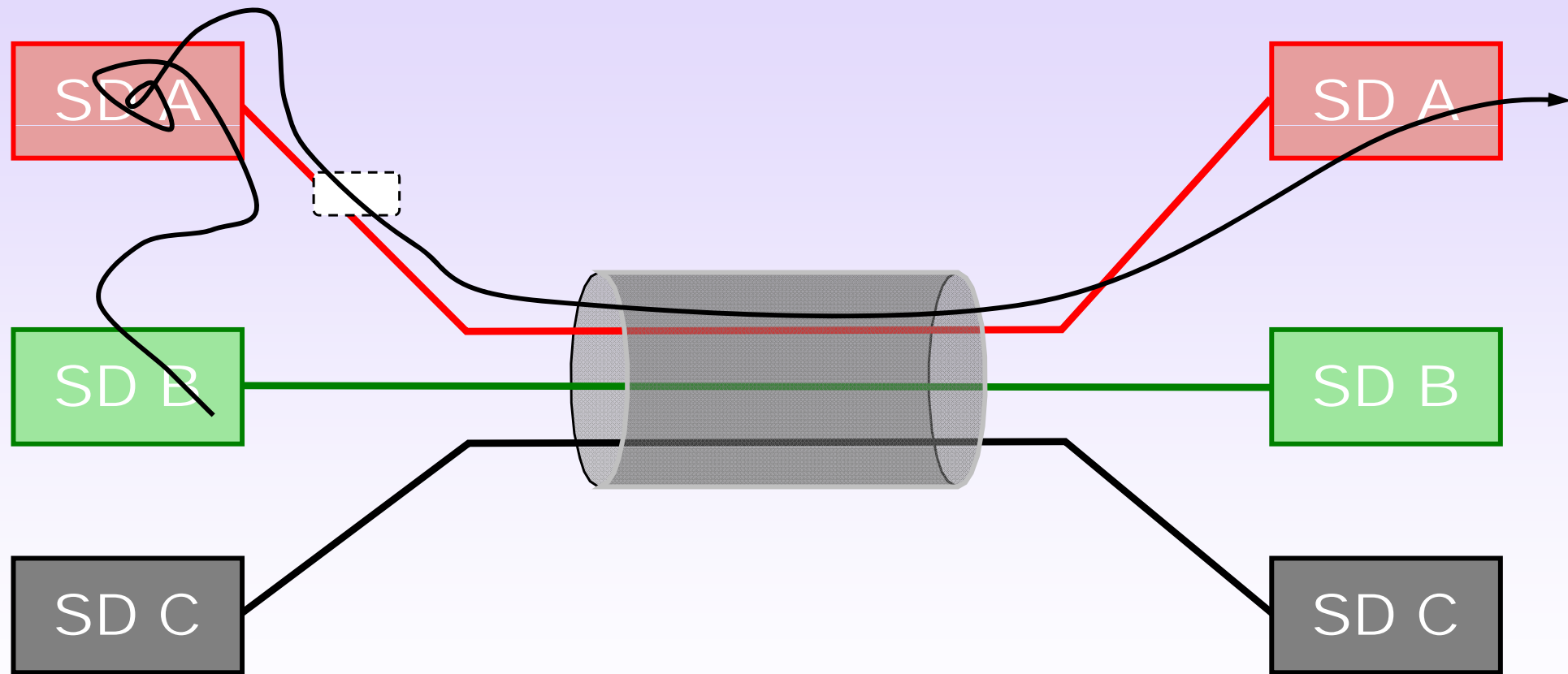


# TIME: Mediation

- An unauthorized party may initiate or cause an information flow, compromising control
- Party 3: An entity that is not authorized to send content or cause content to be sent on certain channels



# Mediation

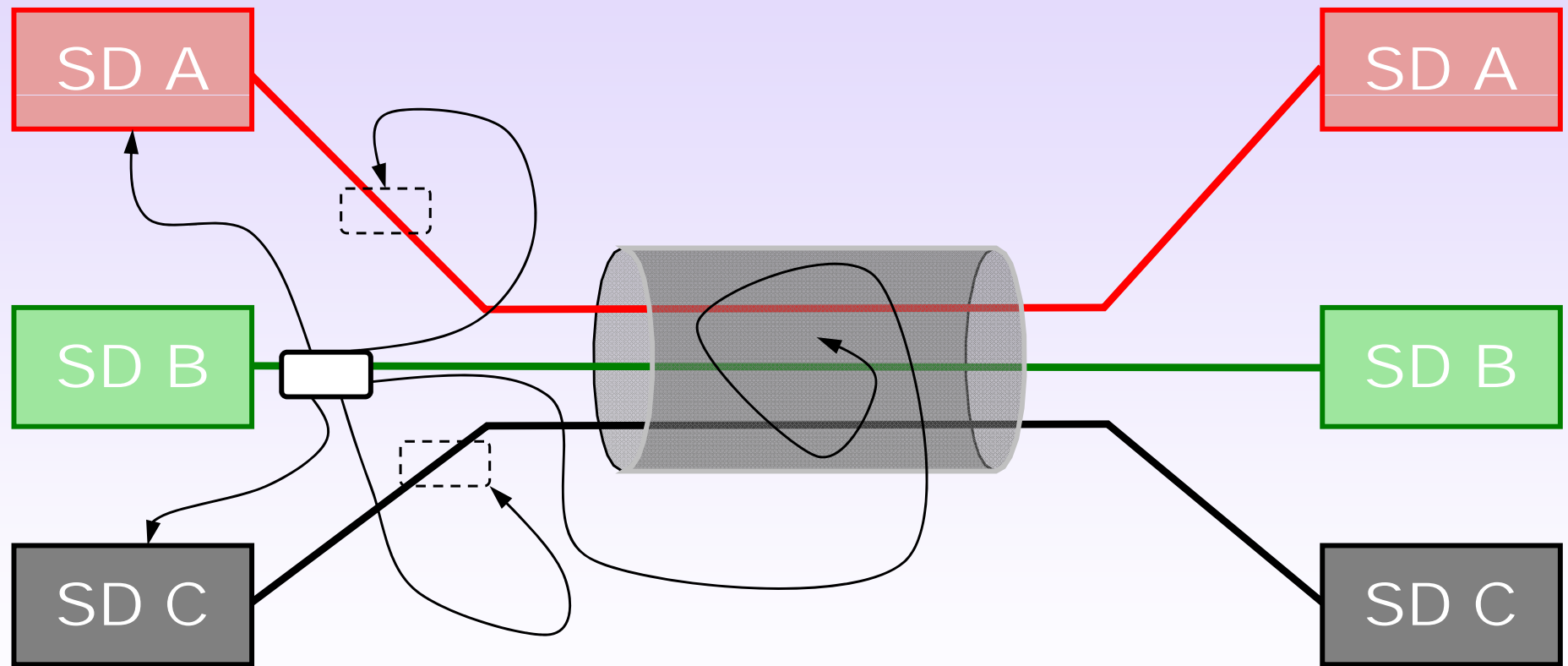


# TIME: Exfiltration

- An unauthorized party may perceive data in a channel, compromising confidentiality
- Party 4: An entity that is not authorized to receive content on certain channels
- Party 5: Software, hardware, or systems that can “see” all traffic of certain channels but are not authorized to receive the content of those channels



# Exfiltration



# Mitigating *TIME* Threats to *NEATness*

- Trustworthy separation enables security policy enforcement to be decomposed along structural lines
- Separation with respect to:
  - Space: Private data remains private
  - Time: Periods processing
  - Information Flow:
    - Only when initiated by authorized subjects,
    - Only delivered to authorized recipients
    - Sender authenticated to receiver



# Benefits of Separation

- Specified interfaces are the only way that information may flow
  - **T**: Inappropriate data types can't be presented to an interface
  - **I**: There can be no infiltration (information pull violation)
  - **M**: There can be no mediation (control violation)
  - **E**: There can be no exfiltration (information push violation)
- Security Policy enforcement behaviors can be localized to each component reference monitor.
- Security policy architecture can then be decomposed as boxes and arrows



# Boxes and Arrows Decomposition

- Boxes encapsulate objects
  - Access only local data and incoming communications
- Arrows are channels for information flow among boxes
  - Strictly unidirectional
  - Absence of arrows is just as crucial as their presence
- Draw enough boxes so that the ones that must be trustworthy are small and simple
  - Assume, for now, that boxes and arrows are “free”



# Least Privilege Boxes

- A module trusted to enforce a system security policy in one layer can be untrusted in a different layer
- When a vulnerability in a reference monitor is found, it can be fixed without having to change anything else.
  - If we don't change anything else, we don't have to recertify the "anything else."
- The architecture has done its job.



# Security Policy Decomposition Benefits

- Each least privilege security policy enforcement box is smaller, simpler, and more readily evaluatable
- Original security policy composition arguments remain unchanged despite obsolescence events
- Systems become more maintainable, adaptable, and extensible
- New threats from smarter and more experienced adversaries can be mitigated without redesigning the entire system



# Compositional Assurance

- Compositional assurance is the path towards the goal of JIT Assurance
  - Construct individual assurance case for each trusted component
  - Provide argument that local policies combine to enforce the overall system policy
- ***Composability enables JIT Assurance***
  - A component can be patched, upgraded, refreshed, or replaced without affecting any other “parts”
  - Total system assurance is maintained at reasonable cost despite obsolescence events



# Survivability

## ✓CONFIDENTIALITY

- Critical Data **PROTECTED**

## ✓INTEGRITY

- Free of Unauthorized Manipulation

## ✓AUTHENTICATION

- Identity Confirmed

## ✓AUTHORIZATION

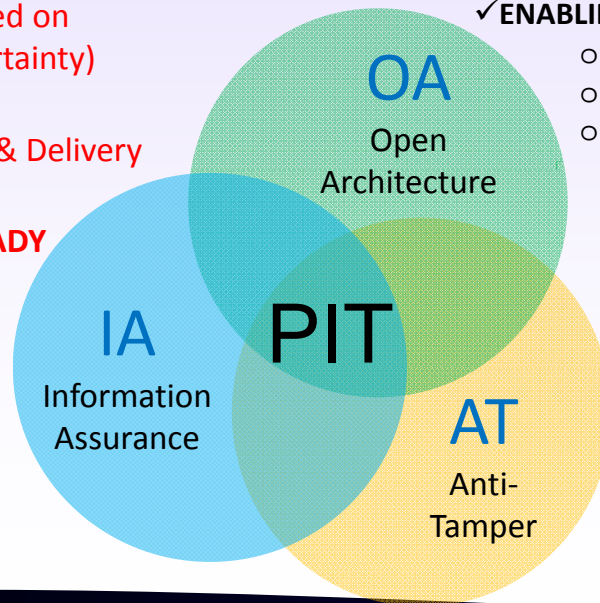
- Privilege Confirmed
- Mutual Suspicion  
(Reduced access based on authentication uncertainty)

## ✓NON-REPUDIATION

- Proof of Data Origin & Delivery

## ✓AVAILABILITY

- Critical functions **READY**



## ✓DESIGNATE KEY INFORMATION EXCHANGES

- Standardize similar areas at Enterprise level across Primes
- Blue force tracking, strike, mission planning , weather, ...

## ✓MODULARITY & VISIABILITY

- Enable affordable, safe and secure Technology Refreshes
- Enable low cost rapid Technology Insertion
- Enable recovery and adaptation against Zero-day Defects

## ✓RE-USEABLE COMPONENTS

- Commercial based standards (POSIX, Open GL) - unmodified
- Published standards (IEEE 1394, 802.11) - unmodified
- Established proprietary standards (USB, Blue Ray) - unmodified

## ✓INTEROPERABILITY & SECURITY (CJCSI 6212.01E)

- Global Network Information Enterprise Architecture
- Support for Distributed degree of trust systems

## ✓ENABLING ENVIRONMENTS

- Infrastructure and Enterprise API's Separable
- Decouple data producers and consumers (cloud computing)
- Register data grams and data streams within metadata registry

## ✓DETERRENCE

- Undesirable Consequences
- Strength of Mechanism

## ✓PREVENTION

- Defense in Depth
- Obfuscation

## ✓DETECTION

- Visual, Alarm, Loss of Function, Attestation
- Monitoring

## ✓RESPONSE

- Destruction, Disabling, Zeroization
- Adaption



# System Life Total Cost of Ownership

Implementation

Certification / Accreditation

Deployment

Operations, Maintenance, and Administration

**Technology Refresh**

**Growing Attack Surface over time**

**Obsolescence Events**



# Summary

- Separation enables JIT Assurance
- Networks of separated modules with proscribed frameworks to integrate them
- Trust of separation infrastructure to be verified.
  - Software implemented separation
    - Deployment of virtualization implementing isolation and redundancy
    - Requires validation of underlying hardware separation mechanisms (i.e., MMU, TPM, VT-d, etc.)
- Verification can be reused during all remaining steps in the system life cycle

